I hereby certify that this correspondence is being electronically submitted to the United States Patent Office on August 11, 2009:

Sarah Knight

Sarah J. Knight, Patent Attorney, Reg. No. 58,722

REQUEST FOR CERTIFICATE OF CORRECTION UNDER 37 CFR 1.322
Docket No. UF.318XC1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Sartaj Kumar Sahni, Haibin Lu
Issued	:	October 28, 2008
Patent No.	:	7,444,318
For	:	Prefix Partitioning Methods for Dynamic Router Tables
Conf. No.	:	3334

ATTN: CERTIFICATE OF CORRECTIONS BRANCH
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CERTIFICATE OF CORRECTION
UNDER 37 CFR 1.322 (OFFICE MISTAKE)

Sir:

A Certificate of Correction for the above-identified patent has been prepared and is attached hereto.

In the left-hand column below is the column and line number where errors occurred in the patent. In the right-hand column is the page and line number in the application where the correct information appears.

Patent Reads:	**Application Reads:**
Cover page, column 1:	Executed Declaration and Power of Attorney submitted August 12, 2004:
"(65) **Prior Publication Data** US 2004/0258061 A1 Dec.23, 2004	--(65) **Prior Publication Data** US 2004/0258061 A1 Dec. 23, 2004
(51) **Int. Cl.** ***G06F 7/00*** (2006.01) ***G06F 17/30*** (2006.01)"	**Related U.S. Application Data** (63) Application No. 10/613,963, filed on Jul. 3, 2003, now U.S. Patent No. 7,509,300. (60) Provisional application No. 60/393,445, filed Jul. 3, 2002. (51) **Int. Cl.** ***G06F 7/00*** (2006.01) ***G06F 17/30*** (2006.01)--
Column 3, line 30:	Page 4, line 26:
"O(T)"	--$O(W)$--
Column 7, line 14:	Page 11, line 6:
"less than s 3 fall"	--less than s **3** fall--
Column 7, line 39:	Page 11, line 23:
"s–16"	--$s = 16$--
Column 8, line 34:	Page 13, lines 8-9:
"partition -1**50**."	--partition –1 **50**.--
Column 9, line 39:	Page 14, line 28:
"i 24,"	--$i \geq 0$,--
Column 14, line 8:	Page 22, line 2:
"MULTIBITh"	-- MULTIBITb--

Column 14, line 11:	Page 22, line 3:
"that of MULTIBITh"	--that of MULTIBITb--
Column 14, line 12:	Page 22, line 4:
"and in MULTIBITh"	--and in MULTIBITb--
Column 14, line 23:	Page 22, line 12:
"s–64)"	--s = 64)--
Column 18, line 15:	Page 28, line 21:
"$\sum_{j=o}^{i} s_j$,"	-- $\sum_{j=0}^{i} s_j$,--
Column 26, line 61:	Page 42, line 6:
"O(logn+maxR)=O(g)."	--$O(\log n + maxR) = O(W)$.--
Column 31, line 20:	Supplemental Amendment Under 37 CFR § 1.111 dated July 22, 2008, claim 1(d):
"storing the prefix"	--storing prefixes--
Column 32, line 37:	2nd Supplemental Amendment Under 37 CFR § 1.111 dated July 23, 2008, claim 12(a):
"value of the bits"	--value of bits--
Column 32, line 51:	2nd Supplemental Amendment Under 37 CFR § 1.111 dated July 23, 2008, claim 13:
"value of the bits"	--value of bits--

True and correct copies of the Executed Declaration and Power of Attorney submitted August 12, 2004, pages 4, 11, 13, 14, 22, 28, and 42 of the specification as filed, the Supplemental Amendment under 37 CFR §1.111 dated July 22, 2008, and the 2nd Supplemental Amendment dated July 23, 2008, which support Applicants' assertion of the errors on the part of the Patent Office, accompanies this Certificate of Correction.

Approval of the Certificate of Correction is respectfully requested.

Respectfully submitted,

Sarah Knight

Sarah J. Knight
Patent Attorney
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SJK/meh/jlr

Attachment: Copy of Executed Declaration and Power of Attorney submitted August 12, 2004
Copy of pages 4, 11, 13, 14, 22, 28, and 42 of the specification
Copy of Supplemental Amendment dated July 22, 2008
Copy of 2nd Supplemental Amendment dated July 23, 2008.
Certificate of Correction

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Mail Stop Missing Parts, Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313 on August 12, 2004.

Margaret Efron, Patent Attorney

Examining Group 2661
Patent Application
Docket No. UF-318XC1
Serial No. 10/719,914
Conf. No. 3334

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	Sartaj Sahni, Haibin Lu
Serial No.	:	10/719,914
Filed	:	November 21, 2003
Art Unit	:	2661
For	:	Prefix Partitioning Methods for Dynamic Router Tables

Mail Stop MISSING PARTS
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

TRANSMITTAL LETTER

Sir:

The above-referenced patent application was filed with an unsigned Declaration (37 CFR 1.63) and Power of Attorney form. Transmitted herewith are two fully executed Declaration (37 CFR 1.63) and Power of Attorney forms for the subject application.

A Notice to File Missing Parts of Nonprovisional Application dated August 4, 2004 was received from the Patent and Trademark Office, and a copy of that Notice is attached hereto.

Please charge the surcharge of $65.00 to Deposit Account No. 19-0065. The Commissioner is hereby authorized to charge any additional fees that may be required to Deposit Account No. 19-0065. Two copies of this transmittal letter are enclosed.

Respectfully submitted,

Margaret H. Efron
Patent Attorney
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Phone No.: 352-375-8100
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Address: 2421 N.W. 41st Street, Suite A-1
Gainesville, FL 32606-6669

MHE/la

Attachments: Two Executed Declaration and Power of Attorney forms; and
Copy of Notice to File Missing Parts of Nonprovisional Application.

DECLARATION (37 C.F.R. § 1.63) AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name; and

I believe that I am the original, first, and sole inventor (if only one name is listed below), or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled PREFIX PARTITIONING METHODS FOR DYNAMIC ROUTER TABLES, specification for which

☐ is attached hereto.
☒ was filed November 21, 2003, Serial No. 10/719,914 .

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (a).

I hereby claim foreign priority benefits under Title 35, United States Code §119 and/or §365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Application Serial No.	Country	Filing Date	Priority Claimed

I hereby claim priority benefits under Title 35, United States Code §119 of any provisional application(s) for patent listed below:

Application Serial No.	Filing Date	Priority Claimed
60/393,445	July 3, 2002	Yes

I hereby claim the benefit under Title 35, United States Code, §120 and/or §365 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (Patented, Pending, Abandoned)
10/613,963	July 3, 2003	Pending

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following persons registered to practice before the Patent and Trademark Office as my attorneys with full power of substitution and revocation to prosecute this application and all divisions and continuations thereof and to transact all business in the Patent and Trademark Office connected therewith: John M. Sanders, Reg. No. 30,126; David R. Saliwanchik, Reg. No. 31,794; Jeff Lloyd, Reg. No. 35,589; Doran R. Pace, Reg. No. 38,261; Jay M. Sanders, Reg. No. 39,355; Jean Kyle, Reg. No. 36,987; James S. Parker, Reg. No. 40,119; Frank C. Eisenschenk, Reg. No. 45,332; Glenn P. Ladwig, Reg. No. 46,853; Margaret Efron, Reg. No. 47,545; and Gwendolyn L. Daniels, Reg. No. 51,594.

I request that all correspondence be sent to:

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Name of Third Joint Inventor

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Date

Signature of Third Joint Inventor

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Name of Fourth Joint Inventor

Residence Citizenship

Post Office Address

Date

Signature of Fourth Joint Inventor

DECLARATION (37 C.F.R. § 1.63) AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name; and

I believe that I am the original, first, and sole inventor (if only one name is listed below), or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled PREFIX PARTITIONING METHODS FOR DYNAMIC ROUTER TABLES, specification for which

☐ is attached hereto.
☒ was filed November 21, 2003, Serial No. 10/719,914 .

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (a).

I hereby claim foreign priority benefits under Title 35, United States Code §119 and/or §365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Application Serial No.	Country	Filing Date	Priority Claimed

I hereby claim priority benefits under Title 35, United States Code §119 of any provisional application(s) for patent listed below:

Application Serial No.	Filing Date	Priority Claimed
60/393,445	July 3, 2002	Yes

I hereby claim the benefit under Title 35, United States Code, §120 and/or §365 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (Patented, Pending, Abandoned)
10/613,963	July 3, 2003	Pending

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following persons registered to practice before the Patent and Trademark Office as my attorneys with full power of substitution and revocation to prosecute this application and all divisions and continuations thereof and to transact all business in the Patent and Trademark Office connected therewith: John M. Sanders, Reg. No. 30,126; David R. Saliwanchik, Reg. No. 31,794; Jeff Lloyd, Reg. No. 35,589; Doran R. Pace, Reg. No. 38,261; Jay M. Sanders, Reg. No. 39,355; Jean Kyle, Reg. No. 36,987; James S. Parker, Reg. No. 40,119; Frank C. Eisenschenk, Reg. No. 45,332; Glenn P. Ladwig, Reg. No. 46,853; Margaret Efron, Reg. No. 47,545; and Gwendolyn L. Daniels, Reg. No. 51,594.

I request that all correspondence be sent to:

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I further request that all telephone communications be directed to:

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Signature of Third Joint Inventor Date

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Name of Fourth Joint Inventor

Residence Citizenship

Post Office Address

Signature of Fourth Joint Inventor Date

Notary Public Notary Seal State of Missouri

ELIZABETH CARY
Cooper County
My Commission Expires
November 4, 2006

Elizabeth Cary
Witnessed that Haibin Lu
signature at this form.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/719,914	11/21/2003	Sartaj Kumar Sahni	UF-318XC1

CONFIRMATION NO. 3334

23557
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FORMALITIES LETTER

OC000000013430164

Date Mailed: 08/04/2004

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is unsigned.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$65** for a Small Entity

- **$65** Late oath or declaration Surcharge.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

T. Ketsela

Customer Service Center
Initial Patent Examination Division (703) 308-1202
PART 2 - COPY TO BE RETURNED WITH RESPONSE

Data structures have been developed called a collection of red-black trees (CRBT) and alternate collection of red-black trees (ACRBT) which support the three operations of a dynamic router-table (longest matching-prefix, prefix insert, prefix delete in $O(\log n)$ time each. (Sahni, S. and K. Kim, "$O(\log n)$ dynamic packet routing," *IEEE Symposium on Computers and Communications* (2002)). The number of cache misses in each structure is also $O(\log n)$. Like the original biased-skip list structure of Ergun, F. *et al.* ("A dynamic lookup scheme for bursty access patterns," *IEEE INFOCOM* (2001)), CRBT and ACRBT adapt so as to perform lookups faster for bursty access patterns than for non-bursty patterns. The ACRBT structure may also be adapted to obtain a collection of splay trees structure, which performs the three dynamic router-table operations in $O(\log n)$ amortized time and which adapts to provide faster lookups for bursty traffic.

Priority search trees have also been used to arrive at an $O(\log n)$ data structure for dynamic prefix-tables. This structure is faster than the CRBT structure described above. A data structure that employs priority search trees and red-black trees for the representation of rule tables in which the filters are a conflict-free set of ranges has also been proposed. This data structure permits most-specific-range matching as well as range insertion and deletion to be done in $O(\log n)$ time each.

Data structures BOB (binary tree on binary tree) have also been developed for dynamic router-tables in which the rule filters are non-intersecting ranges and in which the ties are broken by selecting the highest-priority rule that matches a destination address. Using BOB, the highest-priority rule that matches a destination address may be found in $O(\log^2 n)$ time; a new rule may be inserted and an old one deleted in $O(\log n)$ time. Related structures PBOB (prefix BOB) and LMPBOB (longest matching-prefix BOB) are proposed for highest-priority prefix matching and longest-matching prefixes. These structures apply when all filters are prefixes. The data structure LMPBOB permits longest-prefix matching in $O(W)$ time; rule insertion and deletion take $O(\log n)$ time each. On practical rule tables, BOB and PBOB perform each of the three dynamic-table operations in $O(\log n)$ time and with $O(\log n)$ cache misses. The number of cache misses incurred by LMPBOB is also $O(\log n)$.

In one embodiment of the present invention, a one-level dynamic partition (OLDP) structure **1** is provided in which the root node represents the partitioning of the router-table into $2^s + 1$ partitions. As illustrated in Figure 1, s bits are established so that incoming packets, which specify prefixes and decisions rules for the prefixes, can be partitioned. Prefixes are assessed to determine whether the prefix has a length greater than or equal to s bits. Prefixes having a length that is less than s **3** fall into a designated partition **5** (*i.e.*, partition –1). Prefixes having a length greater than or an equal to s are placed into a partition that corresponds to the value of their first s bits **10**. In a preferred embodiment, nonempty partitions are indexed by an array or a hash table.

For example, where s is established as 3, a prefix whose length is 7 (*i.e.*, the prefix is 0111101*) will be placed in a partition that corresponds to the value of the prefix's s bits. In this particular example, since s=3, the prefix's first s bit is 011. Where a linear binary string valuation system is used, the value of the prefix's first s bit (011) is 3. Thus, the prefix would be placed into partition that corresponds to the value 3. The prefixes in each partition are then represented using dynamic router table data structures **7**.

Compatible dynamic router table data structures include router table data structures that have been disclosed in Lampson *et al.*, "IP lookup using multiway and multicolumn search," *IEEE INFOCOM*, 1998; Ergun *et al.*, "A dynamic lookup scheme for bursty access patterns," *IEEE INFOCOM*, 2001; in U.S. patent Nos. 6,266,706; 6,563,823; 6,522,632; and 5,761,440.

The OLDP of the invention was applied to four different types of known router tables – Paix, Pb, Aads, MaeWest – with $s = 16$. As can be seen in the following Table 1 and in Figures 2A, 2B, 2C, and 2D, OLDP with $s = 16$ is quite effective in reducing both the maximum and the average partition size. In all of the representative databases, partition –1 was substantially larger than the remaining partitions.

As illustrated in Figure 5, a TLDP structure is constructed in a fashion very similar to that of OLDP. As with the OLDP, s bits by which prefixes are partitioned are first established **35** and packets specifying the prefixes and decision rules for the prefixes are received **37**. The prefixes are then partitioned into min(n, $2^s + 1$) partitions using the first s bits of each prefix **40**. Prefixes having a length equal to or greater than s are identified **43** and placed into a partition that corresponds to the value of the prefix's first s bit **45**. The prefixes in each partition are represented using a dynamic routing table structure **47**. Where the prefixes have a length less than s, they are placed into a designated partition, partition –1 **50**.

Then, t bits are established by which the prefixes in partition -1 are further partitioned **53**. Therefore, the prefixes of partition –1, are partitioned into $2^t + 1$ partitions using the first t bits of the prefixes **55**. For prefixes in partition –1 having a length equal to or greater than t bits **57**, they are placed into partitions corresponding to the value of the prefix's first t bit **60** and represented using a dynamic routing table structure **47**. Prefixes having lengths less than t bits are placed into a second designated partition **63** and represented using a dynamic routing structure **47**.

The TLDP of the invention was applied to four different types of known router tables – Paix, Pb, Aads, MaeWest – with $s = 16$ and $t = 8$. When the number of prefixes in each partition is rather small, each partition can be represented using an array linear list in which the prefixes are in decreasing order of length. As can be seen in the following Table 2, TLDP with $s = 16$ and $t = 8$ is quite effective in reducing both the maximum and the average partition size.

Table 2—Statistics of two level partitions ($s = 16$ and $t = 8$)

Database	Paix	Pb	Aads	MaeWest
OLDP Partition –1	586	187	188	268
# of nonempty TLDP partition	91	57	53	67
TLDP Partition –1	0	0	0	0
Max {TLDP partitions}	33	12	15	15
Average number of nonempty TLDP partitions	6.4	3.3	3.5	4.0

Using the prefix partitioning scheme of the present invention, the prefixes in each partition in the router table can be represented using a dynamic router table structure known to the skilled artisan. By doing so, the processing time required to search, insert, and delete tuples in each partition is reduced.

In one embodiment, at least one partition is constructed using a priority search tree (PST) and red black priority search tree (RBPST). With this partition, the functions of search, insert, and delete of tuples are processed expeditiously. It is well known that if R is a set of ranges such that each range represents an address prefix, no two ranges will intersect. As a result, the set of ranges R, is conflict free. To find the most specific range in the partition, the ranges are mapped in 2-dimensional space and the map is transformed so that no two points of the transformed map have the same x-value. Then, the transformed range map is represented as PST. By operating on the PST to define a rectangle comprising the ranges associated with the desired destination address, the most specific range can then be found by locating the point in the defined rectangle having the least x-value. Using this method, the longest prefix is located in the dynamic router table. To insert a prefix into the router data table, the range is mapped and transformed as described above, and the transformed range is inserted into the PST. To delete a prefix, the transformed range is removed from the PST. When the PST is an RBPST, each search, insert, and delete action is performed in $O(\log n)$ time.

Experimental Results

To assess the efficacy of the prefix partitioning schemes of the present invention, these schemes were programmed in C++ and applied as the $OLDP[i]$, $i \geq 0$ structure (as well as the $OLDP[-1]$ structure in the case of one-level dynamic partitioning) to the following dynamic router-table structures: ACRBT (ACBST with each search tree being a red-black tree), CST (ACBST with each search tree being a splay tree), MULTIBIT (16-4-4-4-4 FST; in OLDP applications, 4-4-4-4-FSTs are used for $OLDP[i]$, $i \geq 0$ and a 4-4-4-3-FST is used for $OLDP[-1]$; in TLDP applications, 4-4-4-4-FSTs are used for $OLDP[i]$, $i \geq 0$, 4-3-FSTs for $TLDP[i]$, $i \geq 0$, and a 4-3-FST for $TLDP[-1]$), MULTIBITb (16-8-8 FST; in OLDP

Table 14—Average time to delete a prefix (in μsec) (hash schemes)

Scheme	Paix	Pb	Aads	MaeWest
ACRBT2aH	5.14	3.18	2.81	2.77
CST2aH	3.67	2.25	2.08	2.03
MULTIBIT2aH	1.18	0.91	0.87	0.84
MULTIBITb2aH	1.35	1.07	1.05	0.97
PST2aH	2.01	1.50	1.37	1.18
PBOB2aH	1.30	0.97	0.97	0.77
TRIE2aH	1.67	1.23	1.13	1.00

As can be seen, the use of OLDP and TLDP of the present invention generally resulted in a reduction in the delete time, with the exceptions being MULTIBITb1p and MULTIBITb2p with Paix and Pb. TLDP with array linear lists (*i.e.*, the schemes X2a where X denotes a base scheme such as ACRBT) resulted in the smallest delete times for each of the tested base data structures. The delete time for MULTIBIT2a was between 19% and 62% less than that for MULTIBIT; for PBOB2a, the delete time was between 30% and 39% less than that for PBOB. As was the case for the search and insert operations, ARRAY1p and ARRAY2p have the least measured average delete time. From among the remaining structures, the delete time is the least for MULTIBIT1a, MULTIBIT2a and PBOB2a. For example, on the Paix database, a delete using MULTIBIT2a takes about 6% less time than when PBOB2a is used; on the MaeWest database, a delete using MULTIBIT2a takes about 12% more time than when PBOB2a is used.

Example 1– OLDP and TLDP application to fixed-stride tries

A trie node whose stride is s has 2^s subtries, some or all of which may be empty. A fixed-stride trie (FST) is a trie in which all nodes that are at the same level havr the same stride. The nodes at level i of an FST store prefixes whose length, *length(i)*, is $\sum_{j=0}^{i} s_j$, where s_j is the stride for nodes at level j. In certain instances, the present invention provides for the expansion of a prefix with a nonpermissible length to the next permissible length. In such instances, where a newly created prefix is a duplicate, natural dominance rules are

In one embodiment, the prefixes in the array at a given node are stored in order of increasing length. In a preferred embodiment, *rMax* is determined by examining the prefixes in $ALL(x)$ in increasing order of length; where $ALL'(y)$ is determined by prepending the prefixes in $ALL(x)$ whose length is ≤ the length of *rMax*. The time required to find *rMax* is $O(maxRI)$. This period of time is also required to compute $ALL'(y)$ and $ALL'(x)$. Accordingly, the overall complexity of an insert/delete operation is $O(\log n + maxR) = O(W)$.

As a result of using PBOB trees for HPPT-type dynamic routers, lookup, insert, and delete times are advantageously reduced. Specifically, although the complexity of the disclosed PBOB operations are $O(W)$ for lookup, $O(W)$ for insert, and $O(W)$ for delete, the cache misses of each operation are greatly reduced in comparison to trie.

Example 4—Prefix Partitions Using Longest Matching Prefix Binary on Binary Tree (LMPBOB) for a Longest Matching Prefix Table (LMPT)

In accordance with the present invention, routing functions (*i.e.*, lookup, delete, and insert) can be performed in each prefix partition using dynamic data structures. In one embodiment of the current invention, at least one prefix partition uses a LMPBOB tree for an LMPT. A PBOB as described above is used to represent an LMPT to obtain the same performance as for an HPPT. However, an advantageous reduction in the memory required for the data structure is expected to be realized by replacing the array linear list stored at each node of the PTST (of PBOB described above) by a *W*-bit vector, *bit*. $bit(z)[i]$ denotes the *i*th bit of the bit vector stored in node *z* of the PTST, $bit(z)[i] = 1$ if $ALL(z)$ has a prefix whose length is *i*. *W*-bit vectors have been discussed by Suri *et al.* in their data structures ("Scalable IP lookup with fast updates," *GLOBECOM* (2001)).

Referring now to Figure 17, a flow chart is provided for finding the priority of the longest matching prefix in a LMPBOB that matches a destination address *d*. The process begins by initializing the highest priority to a value, such as zero (0) **177,** initializing a bit position counter to a value, such as zero (0) **180,** and setting the initial node to the root node of a PTST **183**.

COPY

I hereby certify that this correspondence is being electronically transmitted to the United States Patent and Trademark Office on the date shown below:

July 22, 2008

Sarah Knight

Sarah J. Knight, Patent Attorney, Reg. No. 58,722

SUPPLEMENTAL AMENDMENT
UNDER 37 CFR §1.111
Examining Group 2616
Patent Application
Docket No. UF-318XC1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner	:	Sai-Ming Chan
Art Unit	:	2616
Applicants	:	Sartaj Kumar Sahni, Haibin Lu
Serial No.	:	10/719,914
Conf. No.	:	3334
Filed	:	November 21, 2003
For	:	Prefix Partitioning Methods for Dynamic Router Tables

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL AMENDMENT UNDER 37 CFR §1.111

Sir:

This Supplemental Amendment is being submitted to the Patent Office further to the Amendment dated April 24, 2008 that was submitted to the United States Patent Office in response to the Office Action dated April 17, 2008.

Amendments to the Claims are reflected in the listing of claims beginning on page 2 of this paper.

Remarks/Arguments follow the amendment section of this paper.

In the Claims

This listing of claims will replace all prior versions and listings of claims in this application.

1 (currently amended) A method for improving routing operations in dynamic routing tables comprising:

(a) establishing s to be used in a prefix partitioning scheme;

(b) partitioning at least one prefix into up to min(n, 2^s+ 1) partitions, where n is the total number of prefixes;

(c) assessing prefix length with regard to s;

(d) storing ~~the prefix~~ prefixes whose length is larger than or equal to s in a partition that corresponds to the value of the prefix's first s bit;

(e) storing prefixes whose length is smaller than s in a first designated partition; ~~and~~

(f) representing the prefixes in each partition using a router table data structure; and

(g) performing an operation selected from lookup, insert, and delete by using the stored prefixes.

2 (original). The method according to claim 1, wherein the representative router table structure is a dynamic router-table data structure.

3 (original). The method according to claim 2, wherein the dynamic router-table data structure is selected from a group consisting of BOB; PBOB; LMPBOB; B-tree data structure; CRBT; ACRBT; PST; HOT; BOT, and one bit TRIE.

4 (original). The method according to claim 1, wherein the representative router table structure is a static router-table data structure.

5 (original). The method according to claim 4, wherein the static router-table data structure is selected from a group consisting of a linear array; trie-based data structures; and hash trees organized by prefix length.

6 (previously presented). The method according to claim 1, further comprising the steps of:

(a) establishing t to be used for further partitioning the prefixes whose length is smaller than s;

(b) assessing the length of the prefixes stored in the designated partition with regard to t;

(c) partitioning at least one of the prefixes whose length is larger than or equal to t in up to min (n, $2^t + 1$) partitions, wherein the prefix whose length is smaller than s and larger than or equal to t is placed in a partition based on the value of the prefix's first t bit; and

(d) storing the prefixes whose length is smaller than s and t into a second designated partition.

7 (original). The method according to claim 1, further comprising the step of indexing nonempty partitions using an array or a hash table.

8 (currently amended). A computer program product recorded on computer readable medium for routing packets comprising; a computer readable medium for receiving packets specifying prefixes and decision rules for the prefixes; a computer readable medium for establishing s bits to be used in a prefix partitioning scheme; a computer readable medium for matching, inserting, or deleting prefixes in a partitioning tree; and a computer readable medium for performing steps of multilevel partitioning, said steps comprising:

(a) establishing s to be used in a prefix partitioning scheme;

(b) partitioning at least one prefix into up to min (n, $2^s + 1$) partitions, where n is the total number of prefixes;

(c) assessing prefix length with regard to s;

(d) storing prefixes whose length is larger than s in a partition that corresponds to the value of the prefix's first s bit;

(e) storing prefixes whose length is smaller than s in a first designated partition; and

(f) representing the prefixes in each partition using a router table data structure.

9 (original). The computer program according to claim 8, wherein the dynamic router-table data structure is selected from a group consisting of BOB; PBOB; LMPBOB; B-tree data structure; CRBT; ACRBT; PST; HOT; and BOT.

10 (original). The computer program according to claim 8, wherein the representative router-table structure is a static router-table data structure.

11 (original). The computer program according to claim 10, wherein the static router-table data structure is selected from a group consisting of a linear array; trie-based data structures; and hash trees organized by prefix length.

12 (original). The computer program according to claim 8, wherein the computer readable medium for performing the steps of multilevel partitioning further comprises the steps of:

(a) establishing t to be used for further partitioning the prefixes whose length is smaller than s;

(b) assessing the length of the prefixes stored in the designated partition with regard to t;

(c) partitioning at least one of the prefixes whose length is larger than or equal to t in up to min (n, 2^t + 1) partitions, wherein the prefix whose length is smaller than s and greater than or equal to t, is placed in a partition based on the value of the prefix's first t bit; and

(d) storing the prefixes whose length is smaller than s and t into additional bits into a second designated partition.

13 (original). A computer system comprising: a memory containing a partitioning routing table constructing program having functions for constructing a routing table with partitions based on the first *s* bits of a prefix; wherein the prefixes in each partition are represented by a router table data structure; and a processor for executing the partitioning routing table constructing program.

14 (original). The computer system according to claim 13, wherein the partitioning routing table constructing program further includes functions for constructing partitions based on the first *t* bits of a prefix.

Remarks

Claims 1-14 are pending in the subject application. By this amendment, claims 1 and 8 have been amended. No new subject matter has been added by this amendment.

The applicant wishes to thank Examiner Chan for the courtesy extended to the undersigned during the telephonic Examiner Interview conducted July 22, 2008. This response and the amendments set forth herein are submitted in accordance with the substance of that interview and constitute a summary of that interview.

The Commissioner is hereby authorized to charge any fees under 37 CFR §§1.16 or 1.17 as required by this paper to Deposit Account No. 19-0065.

The applicants also invite the Examiner to call the undersigned if clarification is needed on any of this response, or if the Examiner believes a telephone interview would expedite the prosecution of the subject application to completion.

Respectfully submitted,

Sarah Knight

Sarah J. Knight
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COPY

I hereby certify that this correspondence is being electronically transmitted to the United States Patent and Trademark Office on the date shown below:

July 23, 2008

Sarah Knight

Sarah J. Knight, Patent Attorney

2nd SUPPLEMENTAL AMENDMENT
UNDER 37 CFR §1.111
Examining Group 2616
Patent Application
Docket No. UF-318XC1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner	:	Sai-Ming Chan
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Applicants	:	Sartaj Kumar Sahni, Haibin Lu
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For	:	Prefix Partitioning Methods for Dynamic Router Tables

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

2nd SUPPLEMENTAL AMENDMENT UNDER 37 CFR §1.111

Sir:

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Amendments to the Claims are reflected in the listing of claims beginning on page 2 of this paper.

Remarks/Arguments follow the amendment section of this paper.

In the Claims

This listing of claims will replace all prior versions and listings of claims in this application.

1 (currently amended) A method for improving routing operations in dynamic routing tables comprising:

(a) establishing s to be used in a prefix partitioning scheme, where s denotes a pre-established value of bits of the prefixes;

(b) partitioning at least one prefix into up to min(n, 2^s+ 1) partitions, where n is the total number of prefixes;

(c) assessing prefix length with regard to s;

(d) storing prefixes whose length is larger than or equal to s in a partition that corresponds to the value of the prefix's first s bit;

(e) storing prefixes whose length is smaller than s in a first designated partition;

(f) representing the prefixes in each partition using a router table data structure; and

(g) performing an operation selected from lookup, insert, and delete by using the stored prefixes.

2 (original). The method according to claim 1, wherein the representative router table structure is a dynamic router-table data structure.

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5 (original). The method according to claim 4, wherein the static router-table data structure is selected from a group consisting of a linear array; trie-based data structures; and hash trees organized by prefix length.

6 (currently amended). The method according to claim 1, further comprising the steps of:

(a) establishing t to be used for further partitioning the prefixes whose length is smaller than s, where t denotes a second pre-established value of bits of the prefixes;

(b) assessing the length of the prefixes stored in the designated partition with regard to t;

(c) partitioning at least one of the prefixes whose length is larger than or equal to t in up to min (n, $2^t + 1$) partitions, wherein the prefix whose length is smaller than s and larger than or equal to t is placed in a partition based on the value of the prefix's first t bit; and

(d) storing the prefixes whose length is smaller than s and t into a second designated partition.

7 (original). The method according to claim 1, further comprising the step of indexing nonempty partitions using an array or a hash table.

8 (currently amended). A computer program product recorded on computer readable medium for routing packets comprising[[;]]: a computer readable medium for receiving packets specifying prefixes and decision rules for the prefixes; a computer readable medium for establishing s bits to be used in a prefix partitioning scheme; a computer readable medium for matching, inserting, or deleting prefixes in a partitioning tree; and a computer readable medium for performing steps of multilevel partitioning, said steps comprising:

(a) establishing s to be used in a prefix partitioning scheme, where s denotes a pre-established value of bits of the prefixes;

(b) partitioning at least one prefix into up to min (n, $2^s + 1$) partitions, where n is the total number of prefixes;

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9 (original). The computer program according to claim 8, wherein the dynamic router-table data structure is selected from a group consisting of BOB; PBOB; LMPBOB; B-tree data structure; CRBT; ACRBT; PST; HOT; and BOT.

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11 (original). The computer program according to claim 10, wherein the static router-table data structure is selected from a group consisting of a linear array; trie-based data structures; and hash trees organized by prefix length.

12 (currently amended). The computer program according to claim 8, wherein the computer readable medium for performing the steps of multilevel partitioning further comprises the steps of:

(a) establishing t to be used for further partitioning the prefixes whose length is smaller than s, where t denotes a second pre-established value of bits of the prefixes;

(b) assessing the length of the prefixes stored in the designated partition with regard to t;

(c) partitioning at least one of the prefixes whose length is larger than or equal to t in up to min (n, $2^t + 1$) partitions, wherein the prefix whose length is smaller than s and greater than or equal to t, is placed in a partition based on the value of the prefix's first t bit; and

(d) storing the prefixes whose length is smaller than s and t into additional bits into a second designated partition.

13 (currently amended). A computer system comprising: a memory containing a partitioning routing table constructing program having functions for constructing a routing table with partitions based on the first *s* bits of a prefix, where *s* denotes a pre-established value of bits of the prefix; wherein the prefixes in each partition are represented by a router table data structure; and a processor for executing the partitioning routing table constructing program.

14 (currently amended). The computer system according to claim 13, wherein the partitioning routing table constructing program further includes functions for constructing partitions based on the first *t* bits of a prefix, where *t* denotes a second pre-established value of bits of the prefix.

Remarks

Claims 1-14 are pending in the subject application. By this amendment, claims 1, 6, 8, and 12-14 have been amended. No new subject matter has been added by this amendment.

The applicant wishes to thank Examiner Chan for the courtesy extended to the undersigned during the telephonic Examiner Interview conducted July 23, 2008. This response and the amendments set forth herein are submitted in accordance with the substance of that interview and constitute a summary of that interview.

The Commissioner is hereby authorized to charge any fees under 37 CFR §§1.16 or 1.17 as required by this paper to Deposit Account No. 19-0065.

The applicants also invite the Examiner to call the undersigned if clarification is needed on any of this response, or if the Examiner believes a telephone interview would expedite the prosecution of the subject application to completion.

Respectfully submitted,

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,444,318

APPLICATION NO.: 10/719,914

DATED : October 28, 2008

INVENTORS : Sartaj Kumar Sahni, Haibin Lu

It is certified that errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Cover page,
Column 1,
"(65) **Prior Publication Data**
US 2004/0258061 A1 Dec. 23, 2004

(51) **Int. Cl.**
G06F 7/00 (2006.01)
G06F 17/30 (2006.01)"

should read

--(65) **Prior Publication Data**
US 2004/0258061 A1 Dec. 23, 2004

Related U.S. Application Data
(63) Application No. 10/613,963, filed on Jul. 3, 2003, now U.S. Patent No. 7,509,300.

(60) Provisional application No. 60/393,445, filed Jul. 3, 2002.

(51) **Int. Cl.**
G06F 7/00 (2006.01)
G06F 17/30 (2006.01)--.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	:	7,444,318	Page 2 of 3
APPLICATION NO	:	10/719,914	
DATED	:	October 28, 2008	
INVENTORS	:	Sartaj Kumar Sahni, Haibin Lu	

It is certified that errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 3,
Line 30, "O(T)" should read --$O(W)$--.

Column 7
Line 14, "less than s 3 fall" should read --less than s **3** fall--.
Line 39, "s–16" should read --$s = 16$--.

Column 8
Line 34, "partition -**150**." should read --partition –1 **50**.--.

Column 9
Line 39, "I 24," should read --$i \geq 0$,--.

Column 14
Line 8, "MULTIBITh" should read --MULTIBITb--.
Line 11, "that of MULTIBITh" should read --that of MULTIBITb--.
Line 12, "and in MULTIBITh" should read --and in MULTIBITb--.
Line 23, "s–64)" should read --s = 64)--.

Column 18
Line 15, "$\sum_{j=o}^{i} s_j$," should read -- $\sum_{j=0}^{i} s_j$,--.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,444,318

APPLICATION NO.: 10/719,914

DATED : October 28, 2008

INVENTORS : Sartaj Kumar Sahni, Haibin Lu

It is certified that errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 26
Line 61, "O(logn+maxR)=O(g)" should read --$O(\log n + maxR) = O(W)$--.

Column 31
Line 20, "storing the prefix" should read --storing prefixes--.

Column 32
Line 37, "value of the bits" should read --value of bits--.
Line 51, "value of the bits" should read --value of bits--.

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